**INDUCTOR TESTING CAN DETERMINE THE VALUES OF IMPENDATION, INDUCTIVE REACTANCE AND INDUCTANCE IN THE INDUCTOR**


## Abstract

An inductor is a type of electronic component found in electronic equipment. An inductor functions to store electrical energy through the magnetic field generated by the coil, which can change significantly. There are several coils in the inductor made of ferromagnetic (Fe), paramagnetic (Cu) and diamagnetic (Al) materials. In this study, there are four inductors with different capacities whose resistance, voltage and current values can be measured, then analyzed to obtain the inductive impedance and inductance values in Henry units. The measurement process uses a measuring tool, namely an Avometer and a DC power source. Measurements are carried out by creating a circuit on the terminal board, then connecting it to the power source and recording the results. The inductors measured were 1000Wdg, 500Wdg, 33mH and 10mH. The test results that were carried out showed that the values produced always varied, where the highest resistance was 20 Ohms on the 1000Wdg Inductor and the lowest was 1.3 Ohms on the 33mH Inductor. Then the highest voltage is 1.5 Volts on the 33mH Inductor and the lowest value is 1.1 Volts on the 10mH Inductor. The measurement results on the inductor can be reanalyzed mathematically to obtain the Impedance (Z), Inductance (XL) and Inductance (L) values. So based on the analysis results on four inductors, the highest impedance value is 20 Ohm, the lowest is 0.52 Ohm, the highest inductive value is 100 Ohm, the lowest is 1 Ohm and the highest inductance is 31.4 Henry, the lowest is 0.31 Henry.



**Keywords**: Impedance, Inductance and Inductance in Inductors.




## 1. Introduction

With the increasingly advanced development of technology in the field of electronics, the need for electronic equipment components is increasing and human dependence on this equipment is increasing. In electronic circuits, there are various basic components such as resistors, inductors, capacitors, etc. There are many measuring instruments that can measure the value of a component, such as the value of an ohmmeter, inductance meter, or capacitance meter, etc. An inductor is an electronic component that can store electrical energy in a magnetic field generated by the electric current passing through it. The inductor's capability can be determined by the inductance in henry units. Several previous studies have stated that

[1] Hanna Fury Nur Ramdany, (2016) in the journal entitled "Digital Inductance Measuring Instrument Based on Atmega 32" stated that this digital inductance meter can be used to measure inductances with a measurement level or range between 20µH –100mH. [2] Moch. Dhofir (2009) in the journal entitled "The Effect of Inserting Inductors and Connections of 20 kV Overhead Lines and Distribution Cables on the Propagation of Surge Voltage Waves" argues that the effect of inserting L series or C parallel between two different lines on the propagation of surge waves coming from various forms and the greater the frequency value and the value of the inserted component, the greater the level of damping on the wave. [3] Divers Starles Badaruni, (2018) in a journal entitled Design and Making of Basic Electronics Practical Trainers in Electronics and Instrumentation Laboratories. Has stated that practical demonstration tools can be used to assemble a basic electronic circuit as an initial stage in getting to know and studying the world of electronics. [4] Pramushinta Arum Pynanjung, (2014) in a journal entitled Optimization of Circuits and Coil Materials in Wireless Electrical Transfer Circuits Regarding the Range of Electrical Energy Transmission. It has been argued that the results of coil testing and optimization with a transfer circuit on a 32 cm diameter copper coil in a transmitter circuit made center tapped with 24 coils and 12 coils, can light an LED lamp at a distance of 50 cm. The reference voltage provided is ± 12 Volts and requires a frequency in the isolator circuit of ± 107.105 kHz. [5] Vera Pangni Fahriani, (2022) In a journal entitled Inductance Capability of ASTM A48 Cast Iron, Nichrome and Monel Alloy 400 Inductor Metal Core Materials Against Variations in Electrical Input and Windings. It has been argued that the test results on new types of metal with varying voltages, turns and working frequencies of 4.5 V - 24 V and turns of 150 to 1000 turns, and a frequency of 50 Hz, where by increasing the applied voltage the number of turns on the inductor will increase and the resulting inductance value will be high.

## 2. Theory

An inductor is a passive electronic component that can store electrical energy in a magnetic field created by an electric current passing through it. The ability of an inductor to store magnetic energy is determined by its inductance, in units of Henry. Typically an inductor is a conducting wire formed into a coil, the coils help create a strong magnetic field inside the coil due to Faraday's law of induction. An inductor is one of the basic electronic components used in circuits where the current and voltage change due to the inductor's ability to process alternating current.

**1. Symbol inductor**

The inductor symbol, both in circuit form and in coil form, is found in an inductor. To understand the inductor symbol, see the image below.


a b

Figure 1.a and b Inductor symbols

In figure 1 a, b above is the form of the circuit symbol and inductor components, where in the inductor body there are 3 small parts, namely; coil connection, air core and coil winding. The coil connection is the leg part of an inductor, then the distance between the turns on the inductor is called the air core and the shape of the turns of a copper wire is called a coil. To determine the inductance value of an inductor (coil) depends on 4 factors, including:

a. The inductance value of an inductor depends on its coil.

b. The number of turns, where the more turns, the higher the inductance value.

c. The diameter of the inductor, where the larger the diameter, the higher the resulting inductance value.

d. The shorter the core permeability of the inductor, the higher the inductance value.

**2. Types of Inductors**

There are several types of inductors. To learn more about the types and definitions of each inductor, see the image below.

(a) (b) (c) (d)

(e) (f)

Figure 2.2 a,b,c,d,e,f Inductor Components

a. Ari Core Inductor

This type of inductor is found in many RF circuits. This type of inductor is widely used because it has no energy loss and very low air permeability. This type of inductor provides a very low inductance value.

b. Iron Core Inductor

This type of inductor is made of solid iron and can produce very large eddy and hysteretic currents. Therefore, it is only used for low-power, high-power applications such as PDI power supplies, inverters, and others, and produces very high inductance.

c. Ferrite Core Inductor

This type of inductor consists of a ferrite core made of compacted ceramic powder. Ferrite core inductors are most commonly used in electronic equipment, especially in high-frequency circuits, due to their low hysteresis and low eddy currents.

d. Torroidal Core Inductor

This type of inductor is circular in shape. It has a very high inductance value and Q factor. This inductor is used in power and switching circuits.

e. Laminated Core Inductor

This inductor core is made of a laminated arrangement of thin steel sheets. The thin steel layers are firmly bonded together to form a solid core and separated by an insulating layer to prevent eddy currents.

f. Variable Inductor

An inductor whose inductance can be adjusted as desired. The core of a variable inductor is generally made of ferrite and can be rotated.

The functions of an inductor in an electronic circuit include:

- Energy storage in the form of a magnetic field
- Filtering in power supply circuits
- Tuning
- Restraining alternating current (AC)
- Passing direct current (DC)
- Converting DC to AC using a magnetic field

Based on their use, inductors operate at:

- High frequencies in antenna coils and isolators
- Medium frequencies in multi-frequency coils

- Low frequencies in input transformers, output transformers, speaker coils, power transformers, relay coils, and filter coils.

**3. The working principle of an inductor**

To understand how an inductor works, first you need a simple electrical circuit consisting of an incandescent light bulb connected in parallel with an inductor, then this circuit with a voltage source that is generated is a DC voltage from a battery connected in parallel with the lamp via a switch. The working process by pressing the switch button, the light bulb will light up brightly at first before dimming to a lower light intensity. The effect that occurs when the switch is turned off can experience higher brightness so that the lamp stops emitting light completely. due to inductance when current begins to flow through the coil it can produce a magnetic field, the current flowing through the coil can produce a second current in the opposite direction. However, when a magnetic field is formed, the current returns to normal. When the switch is turned off, the magnetic field can compensate and produce an electric current through the coil in the magnetic field. When an inductor loses its voltage source, it can produce a momentary voltage. When an inductor loses its voltage source, it can generate a momentary voltage. When the inductor receives a voltage, the inductor becomes a core with magnetic properties (iron core). This characteristic can be utilized in various electronic devices. The inductance of the coil in an inductor causes a magnetic flux to be generated around it. where the stronger the magnetic flux, the greater the resulting inductance value. to increase the inductance value of the coil or coil by increasing the number of turns of wire, with the diameter or length of the core (central core) on the inductor can be replaced with a core using a ferromagnetic material similar to the soft iron material of the ferrited inductor type. Ferromagnetic materials such as soft iron, cobalt, or nickel, among others, must be used as cores to increase the inductance of the coil, and the lines of force generated by the stronger ferromagnetic material. The electromagnetic principles of inductors are as follows:

**a. Direct Inductance**

In direct inductance, the flow of electric current through a cable causes magnetic lines of force to form. If the current flows through the spool or coil, it can generate a magnetic field with a strength equal to the magnetic lines of force, which is directly proportional to the product of the number of turns in the coil.

**b. Alternating Inductance**

This alternating inductance is two coils in an inductor that are close together. Where coil L1 is supplied with AC current, magnetic flux can be generated through coil L2, which can generate an EMF (electromotive force). The effect on coil L2 due to the proximity of the coils can cause mutual inductance. This is often found in power transformer equipment.

**c. Alternating Inductance**

Alternating inductance is the result of two adjacent coils in an inductor. Where coil L1 is supplied with AC current, magnetic flux can be generated, and through coil L2, an EMF (electromotive force) can be generated. The proximity of the coils to coil L2 can cause mutual inductance. This is often found in power transformers. Analyzing the resistance value of an inductor can be done using a circuit, including:

a. Using a Series Inductor Circuit

Inductance can be calculated using a series inductor circuit, where the circuit consists of two or three inductors arranged in parallel in series. The resulting value from the calculation using this series circuit is obtained by adding the total inductance value:

L Total = L1 + L2 + L3 +…+Ln……………………………………….(1)

b. Using Parallel circuit

Inductors can be calculated using a parallel circuit, where the circuit is arranged in parallel consisting of 2 or more inductors in a series form. To get the number of inductor values in series, use the equation below.

$$\frac{1}{L\ total} = \frac{1}{L1} + \frac{1}{L2} + \frac{1}{L3} \ldots \frac{1}{Ln} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

To obtain the analysis value for calculating impedance (Z), inductive reactance (XL) and inductor capacity (L) in an inductor, it can be calculated using the following equation.

Z = V/R ……………………………………………………………(3)

XL = 2 * F * L ………………………………………………………(4)

L = XL (2$\pi$F) ……………………………………………………(5)

## 3. Research Methods

This research was conducted using a concrete approach and action through measurements of electronic components, specifically inductors. The measurements were conducted to determine the values of resistance, voltage, and current in an inductor. These measurements were then analyzed to obtain the values of impedance, inductance, and inductance contained in the inductor. This research was conducted at the Electronics Workshop (Electronics Laboratory) of the Kupang State Polytechnic. This research used a quantitative approach with an instrument method. The inductor components were tested. The test results were discussed and analyzed systematically to obtain the impedance, inductance, and inductance values of the inductor capacity in Henry units for each inductor. The steps taken during the test were as follows:

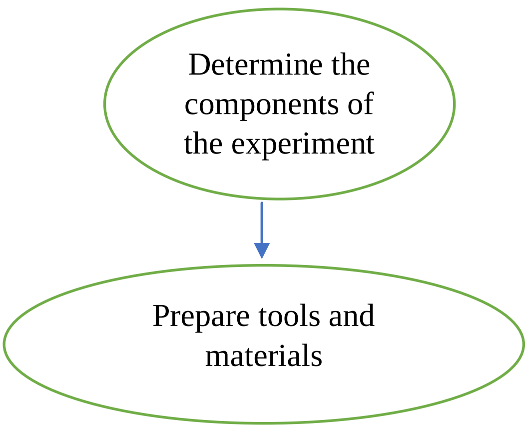
Equipment and Materials

1. Avometer
2. Single-Power Transformer
3. 1000 Wdg Inductor
4. 500 Wdg Inductor
5. 33 mH Inductor
6. 10 mH Inductor

a. Assistive devices

1. Computer/Labtop equipment





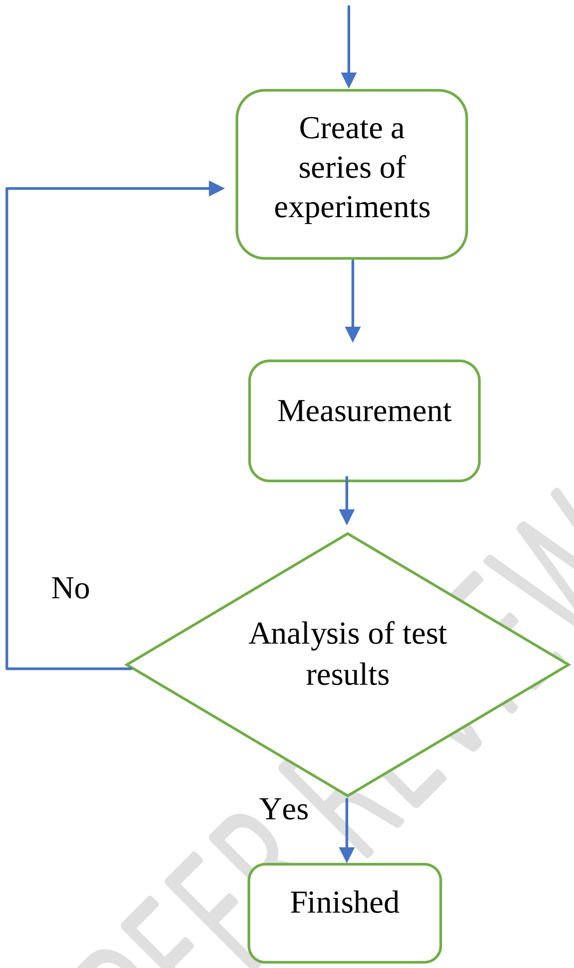



Figure 3.1 Research flow diagram

Data collection in this study was conducted through the following methods:

1. Direct observation of the inductor component testing process
2. Technical measurements using measuring instruments such as an Avometer, a DC single-phase transformer, to measure the voltage and current in the inductor. The Avometer meter measures the resistance of the inductor and records the values of voltage, current, impedance, inductive reactance, and inductance.
3. Documents in the form of photos during testing and record the results of the Resistance, Voltage and Current tests on the inductor components. The test results obtained can be analyzed in table form to make it easier for readers, using quantitative methods by analyzing the values of Impedance, Inductive Reactance and Inductance on the Inductor.

## 4. Discussion

The inductor measurement results are obtained by determining the inductor components, creating a measurement circuit, and then performing measurements on each inductor. To see the inductor test circuit, see the image below.

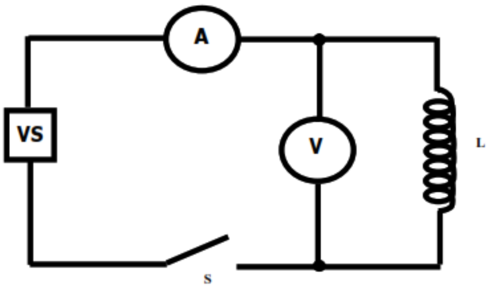
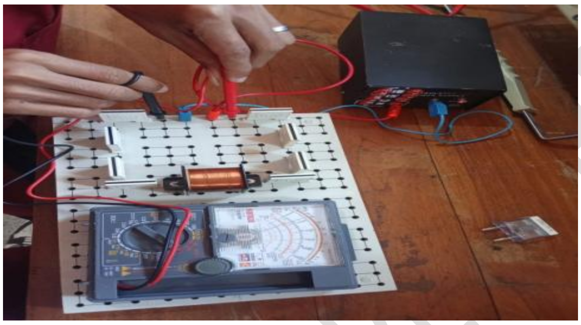
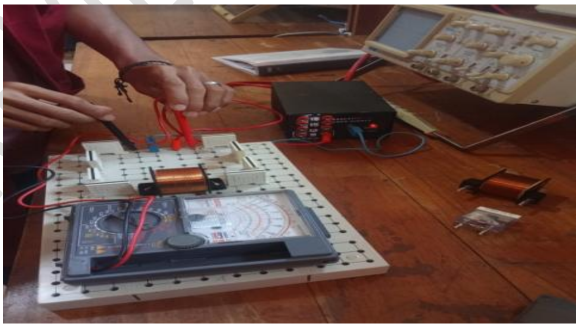



Figure 4.1 Measurement Circuit

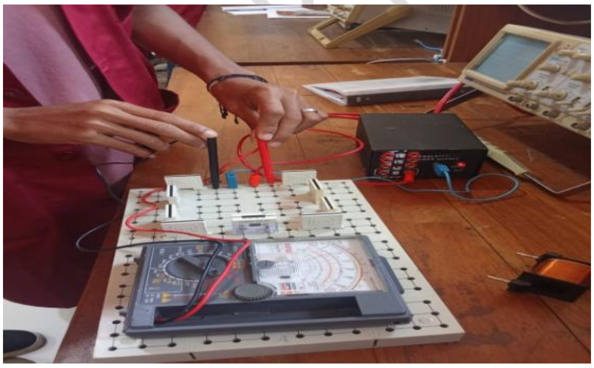
Figure 4.1 above is a form of measurement circuit on the inductor component, this measurement circuit can help researchers in conducting experiments to measure voltage and current in the inductor. In the circuit there are symbols VS is the voltage source, A measures current, V measures voltage then L is the load and S is the switch. The process carried out inductor measurements can be seen in the image below.



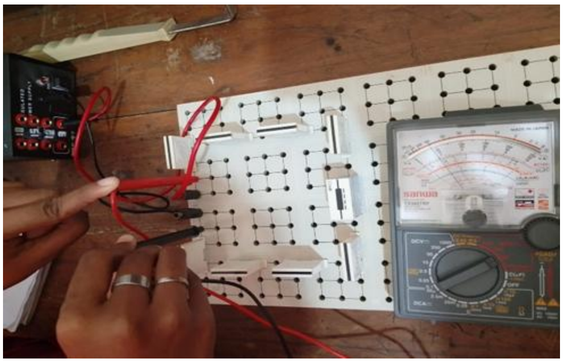
a. 1000 Wdg inductor



b. 500 Wdg inductor



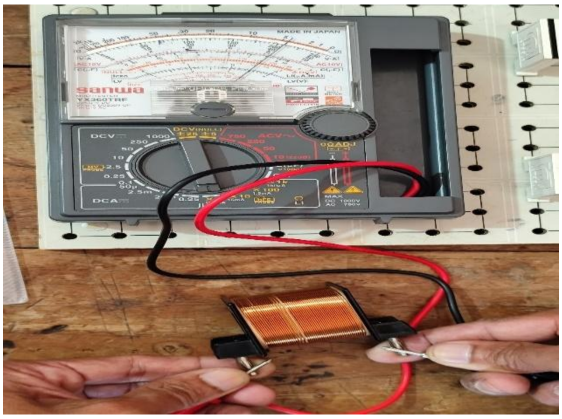
c. 33 mH inductor

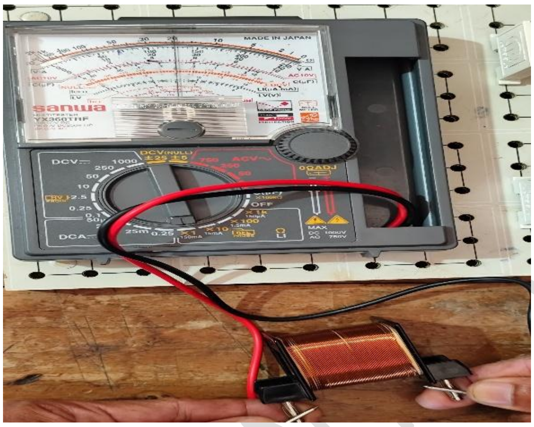


d. 10 mH inductor

Figure 4.2 a,b,c,d Inductor testing

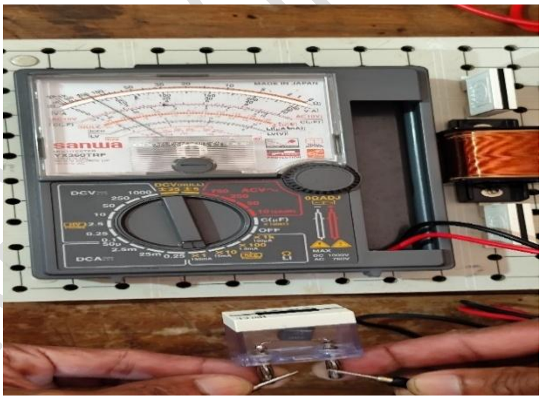
Figure 4.2 above illustrates the inductor measurement process based on a circuit using a terminal board. The circuit used is connected in series from an AC voltage source, then connected via connecting cables from the transformer to the terminals and the load being measured on several inductor components based on the capacity recorded on the inductor body. The resistance measurement process on an inductor can be seen in the figure below.





a. Inductor Resistance 1000 Wdg

b. Inductor Resistance 500 Wdg



c. Inductor resistance 33 mH

d. Inductor resistance 10 mH

Figure 4.3 a.b.c.d Inductor Resistance Measurement

Figure 4.3 above shows the resistance measurement process for each inductor component. The results of the measurements on the inductor components can be presented in a table for ease of reading. The data contained in the table are the results of the voltage, current, and resistance tests on the inductor, as seen in the test results table below.

Table 4.1 Resistance, Voltage and Current Measurements

| NO. | Inductor (mH) L | Measurement | | |
|---|---|---|---|---|
| | | Ohm resistance Ω (R) | Voltage (Volt) | Current (mA) |
| 1 | 1000 Wdg | 20 | 1,4 | 0,07 |
| 2 | 500 Wdg | 4,5 | 1,3 | 0,28 |
| 3 | 33 mH | 1,3 | 1,5 | 0,01 |

| | | | | |
|---|---|---|---|---|
| 4 | 10 mH | 2.1 | 1.1 | 0,52 |

In thickness 4.1 above are the measurement results on three inductors, with a capacity of 1000Wdg 1 piece, 500Wdg 1 piece and 33mH 1 piece. At the time of measurement, the data taken were; the value of resistance, voltage value and current value. It should be noted that for an inductor with an inductance of 1000Wdg, the resistance is 20 Ohms, the voltage is 1.4 volts and the current is 0.07 amperes, then the 500Wdg inductor, the resistance is 4.5 Ohms, the voltage is 1.3 volts and the current is 0.28 amperes, while the 33mH inductor has a resistance of 1.3 Ohms, the voltage is 1.5 volts and the current is 0.01 amperes, 10 mH inductor, the resistance is 2.1 Ohms, the voltage is 1.1 volts and the current is 0.52 amperes. From the test results on the inductor, after the resistance, voltage and current are known, it is necessary to analyze the impedance Z (ohm), inductance XL (ohm) and inductance L (Henry) values as follows.

**Calculation Analysis**

Analysis of the calculation of the impedance (Z) of the inductor using equation 3 above

Analisa perhitungan Impendansi (Z) inductor menggunakan persamaan 3 diatas

$Z = V/I$

Inductor 1000Wdg = 1.4/0.07 = 20 Ohm

Inductor 500 Wdg = 1.3/0.288 = 4.5 Ohm

33 mH inductor = 1.5/0.01 = 1.3 Ohm

10 mH inductor = 1.1/2.1 = 0.52 Ohm

Calculate the inductive reactance (XL) of an inductor using equation 4 above:

$XL = 2 * f * L$

1000Wdg inductor = 2 x 50 x 1000 = 100,000 / 10,000 = 100 Ohm

500Wdg inductor = 2 x 50 x 500 = 50,000 / 1000 = 50 Ohm

33 mH inductor = 2 x 50 x 33 = 3,300 / 1000 = 3 Ohm

10 mH inductor = 2 x 50 x 10 = 1000 / 1000 = 1 Ohm

Calculation analysis of the inductor (L) using equation 5 above:

$L = XL(2\Pi f)$

1000Wdg inductor = 100 (2 x 3.14 x 50) = 31,400 / 1000 = 31.4 Henry

500 Wdg inductor = 50 (2 x 3.14 x 50) = 15,700 / 1000 = 15.7 Henry

33 mH inductor = 3 (2 x 3.14 x 50) = 942 / 1000 = 0.94 Henry

10 mH inductor = 1 (2 x 3.14 x 50) = 314 / 1000 = 0.31 Henry

To make it easier to read the capacity, impedance and inductance of an inductor, based on the analysis results obtained, they can be entered in a table below.

Table 4.2 Results of Z, XL & L Analysis

| The inductor being measured | Impedance(Z) units Ohm | Inductive (XL) unit Ohm | Inductance (L) units of Henry |
|---|---|---|---|
| 1000Wdg | 20 | 100 | 31,4 |
| 500Wdg | 4,5 | 50 | 15,7 |
| 33mH | 1,3 | 3 | 0,94 |
| 10mH | 0,52 | 1 | 0,31 |

Table 4.2 above is the result of analysis on each inductor. The capacity of the 1000Wdg inductor has an impedance value of 20 Ohm, an inductive 100 Ohm inductance of 31.4 Henry. The 500Wdg inductor has an impedance value of 4.5 Ohm, an inductive 50 Ohm and an inductance of 15.7 Henry. The 33mH inductor has an impedance value of 1.3 Ohm, an inductive 3 Ohm and inductance of 0.94 Henry. The 10mH inductor has an impedance value of 0.52 Ohm, inductive 1 Ohm and inductance of 0.31 Henry.

## 5. Conclusion

1. The data presented through a real approach with measurements on 4 inductors. The measurement results can be obtained large values of Resistance, Voltage, Current on each inductor component at large values of Impedance, Inductance and Inductance on the inductor.
2. The results of measurements and analysis on 4 inductors can be stated that, the highest voltage value is 1.5 Volts and the lowest is 1.1 Volts. The highest current is 0.28 mA, the lowest is 0.01 mA. For the highest impedance value of 20 Ohm on the 1000Wdg inductor, the lowest is 0.52 Ohm on the 10 mH inductor. The highest inductive value is 100 Ohm on the 1000Wdg inductor and the lowest is 1 Ohm on the 10mH inductor, Then the capacity with the highest unit (Henry) is 31.4 Henry on the 1000Wdg inductor and the lowest is 0.31 Henry on the 10mH inductor
3. The results of the measurement and analysis research on these four inductors are an additional reference for Basic Electronics Practice and a reference for further research.

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